crease our capital in the shape of available labour. Lessen the amount of crime, and we reduce our police rates.

Feeling deeply the vital importance of the subject with which I have attempted to deal, it is possible I may have been led into a strong expression of feeling at times on the various phases of the question, and by this means have given offence to some. To such I desire to express regret that it should be so, and beg of them to receive these remarks as offered—not in the light of a personal matter, but as an expression of opinion on a public question only, in which each good citizen is bound to act and speak according to the dictates of conscience, and that only.

I have to offer my sincere thanks and acknowledgments to Mr. Archer, the Acting Deputy-Registrar, for his courtesy in furnishing me with much valuable statistical information on the subjects treated of in this paper.

I have also to acknowledge the courtesy of Mr. Moody, the Town-Clerk for East Collingwood, in furnishing me with all the information I required.

ART. XI.—*On Motive Power in Victoria, economically considered.* By FREDERICK ACHESON, C. E.

IN having the honour of laying before the Philosophical Institute certain views on the subject of Motive Power in Victoria, I am impelled thereto, from the conviction of its immense importance to this colony generally, and more especially its bearing upon the development of the vast mineral wealth so lavishly bestowed thereon by the hand of Nature.

It must be admitted that the present exalted position and commercial prosperity of Great Britain substantially date from the successful application of steam as a motive power; the happy effect of that agent in giving an instantaneous stimulus and expansion to the various manufactures, and in creating new sources of industry, has been beneficially felt all over the world, and has accelerated the progress of England's prosperity to such an extent, as to mark the period of its introduction as a great era in her history.

But British manufactures thus suddenly swelled to gigantic proportions, demanded means of dissemination more in unison with their increased development; the same power, therefore, that reinvigorated them, in due course was adapted to pro-

pulsion on land and water, and thus railways and steam vessels became the handmaids of commerce.

If we find in England, where labour is comparatively cheap, the discovery of motive power by steam, followed by the most magnificent results in the creation of manufacturing industry and production of wealth, of what vital importance must the possession of an economical motive agent be in a new colony like Victoria? where labour is dear, and always will be, and the vast undeveloped resources of which present an industrial field for the skilled labour of millions of inhabitants.

But it is one thing to possess a country teeming with natural wealth, and quite another to become possessed of that wealth. Hitherto the colonial mineral resources have only been tested by unskilful manual labour on an isolated system, and by rude machinery, tantamount, as it were, to only scratching the surface. That under such unscientific mode of working and unfavourable circumstances, such surprising returns should have been obtained, as to render this colony the attraction of the whole world, only indicate the practicability of obtaining the most extraordinary results by the application of those principles and agents in manufactures which, in England, have wrought such astonishing success from infinitely poorer materials; in short, Victoria requires for the effectual development of her mineral and other resources, concentration and magnitude of working under recognised scientific principles.

It must be apparent that the principal element in the manufacture or conversion from raw material, must be motive power.

It is now high time that active steps should be taken to place the industrial pursuits of this colony upon a proper footing; excusable as it may have been hitherto under the peculiar circumstances, to leave the production of the staple commodity to the isolated and unskilful resources of private individuals, it now becomes the paramount duty of the "powers that be," to provide such facilities for the prosecution of individual pursuits by the masses of the people as in England are obtained on a large scale by the expenditure of capital.

That the Government have partially acknowledged the justice of this principle, appears from the fact of their having undertaken the construction of a system of railways which will probably cost £10,000,000 sterling: it may not, there-

fore, be altogether inconsistent, or imprudent, in the promoters of a costly scheme of internal communication, to make provision for the traffic by undertaking collateral schemes, tending to give such a successful impetus to industry, as shall draw a vastly increased population to our shores. This is all the more important, as it is impossible to suppose that the present population of 400,000 persons will afford anything like sufficient traffic to pay even working expenses, when the interest on railway construction alone will be half a million sterling per annum.

To carry out, therefore, the scheme of internal communication by railways successfully, it is quite as necessary to provide for the reproductiveness of the capital invested, by making arrangements for the creation of traffic, as it is to construct the lines of railway in the first instance.

It becomes then a vital question as to how the agricultural, mining, and other resources of this colony, can be economised in their development, so as to attain a magnitude and importance such as to render the expenditure upon a system of railways, only consistent with their eventual requirements.

From the fact of industrial pursuits having been hitherto carried on on an isolated system, and for the most part by dear manual labour, or other power expensively applied, it is not to be wondered that the cost of production is discouraging to enterprise, and materially retards the progress of the colony.

To remedy this state of things, it is absolutely necessary that steps be taken to provide cheap motive power on a large scale at the various centres of industry, which shall be available for the use of individuals engaged in various operative pursuits, especially the production of mineral wealth. With such facilities afforded, a vast field for industry will be thrown open to the masses of the people, whose only capital consists in activity, bone, and sinew.

If, for instance, in connection with every Bendigo in Victoria a vast motive agent existed, similar to the Yan Yean Reservoir, of enormous horse power, what immense industrial results such would produce when applied as a motive power in pulverizing quartz, washing auriferous earth, now utterly profitless, and at a fractional part of the existing cost, as I shall presently show? With such agents brought to bear, the hitherto difficult problem of economically developing our mineral wealth, would be immediately solved, and the present working expenses of our gold fields would be reduced to an inconsiderable item.

Agriculture would also receive a great impetus from the existence of an economical motive power being available for the conversion of its products into food.

Admitting, therefore, the vast benefits certain to accrue from the establishment of motive power on a large scale throughout the country, it yet becomes a most important consideration as to what extent such will be reproductive for the large amount of capital that must necessarily be invested therein; for experience has shown that great undertakings, such as railways, that produce immense beneficial results to the community at large, are frequently sources of loss and ruin to their proprietors as speculations. I therefore propose to show further on, that the establishment of motive power over the country will not only be the means of developing an unparalleled amount of prosperity, but that, viewed singly in the light of investment of capital, will be eminently reproductive.

In the selection of motive power for Victoria, the choice evidently lies between steam and water power. The difficulties and expense that attend the erection and maintenance of steam power up the country, present serious objections to its use; while the amount of capital consumed thereby being for perishable works, would be nearly two-thirds of that for water power, being for comparatively imperishable works; while the working expenses of steam would be, as I shall presently show, more than double that of water power. It is, however, quite unnecessary to educe any arguments in favour of the great superiority of water power over steam: such being only too apparent from experience.

The physical structure of Victoria is singularly favourable to the formation of water power by means of storage reservoirs, intersected, as it is, from east to west with the great Dividing Range: the lines of drainage flow therefrom with a rapid fall southward into the sea, and northward into the river Murray. In the vicinity of these ranges, along the water courses, many localities present themselves as suitable for the storage of water on a large scale; among which the Yan Yean Reservoir is a notable example. Throughout the country also the deep narrow valleys of the creeks, frequently one hundred and fifty feet deep, present favourable sites for making a succession of dams, by means of which large quantities of water can be stored and conveyed under pressure to lower levels: the water so collected in a deep narrow reservoir presents a small area to evaporation.

In the vicinity of the gold fields the elevations of the pri-

mitive formations, such as Mount Alexander, forming the sources of the creeks, present a height of fall above the country a few miles off, which can be usefully made available for conveying under pressure stored water from the sources to such distances as will give the desired fall and consequent power.

That water power may be obtained in almost every part of Victoria, does not admit of a doubt: the real question is, whether the establishment of water power throughout the country will be reproductive for the amount of capital sunk therein.

To investigate therefore the whole financial aspect of the question, and arrive at the probable cost and capabilities of storage reservoirs as prime movers in Victoria, I shall take the Yan Yean reservoir as being a great example, and estimate its reproductive capabilities, viewed as a motive power applied to various industrial purposes.

It may be remembered that the amount of water available from the Yan Yean reservoir for the supply of Melbourne, was estimated some time back by a committee of the late Philosophical Society at 22,000,000 cube yards per annum. The results since obtained in the reservoir appear to bear out this estimate. Mr. Hodgkinson's estimate of supply did not materially differ from the above, while he demonstrated the possibility of immensely increasing the supply by means of catchwater drains. I will, therefore, calculate the horse-power upon the committee's estimate of supply, although I believe it will be considerably exceeded by the result.

22,000,000 cube yards divided by 309, the number of working days in the year, gives 71,197 cube yards as the daily supply, weighing 56,636 tons. But 21,214 tons falling 1 foot in 24 hours, is 1-horse power: therefore the daily supply of 53,636 tons is 2½-horse power per foot of fall. This multiplied by the head of 600 feet will give the total theoretical water power of the reservoir equal to 1500 horses.

Of this immense theoretical power, 80 per cent., or 1200 horses can be made available by means of the Turbine or horizontal water wheel, which from its simple and inexpensive construction is admirably adapted for attaining a rotatory motion from the pressure of water, and has been most successfully employed in giving motion to machinery in factories, while acting under different heads, up to 350 feet. By the intervention of this simple engine, the latent power of

the reservoir may be easily and economically brought to bear upon various industrial purposes.

The cost of steam power in Melbourne will form a correct basis for determining the commercial value of a horse power, which is based on the following figures, representing, for the most part, the actual cost at Mr. Fulton's establishment.

Expenses, including coals, attendance, wear and tear, tallow and oil—per horse power per hour	3.5d.
Then allowing interest at 5 per cent. on £300 per horse power, for erections, and machinery	.2d.
Management, and maintenance of buildings .	.1d.
Actual working expenses per horse power, per hour	3.8d.

This amounts to £139 per horse power per annum, being the actual working expenses of steam power. Now, if this power were leased out for manufacturing purposes, and a profit of 50 per cent. on the cost be assumed as legitimate, the whole commercial value of a horse power would be 5.7d. per hour.

Valued at this rate, the whole motive power of the Yan Yean reservoir of 1200 horses, would be worth £211,356 per annum.

I would estimate the working expenses of the Yan Yean motive power as follows:—

Interest on cost of works, embracing the reservoir and pipes to Melbourne, &c., &c., arranged for motive engines or turbines, buildings, &c. being 5 per cent. on 600,000*l.* for reservoir works, and 5 per cent. on 200,000*l.* for motive engines, buildings, &c. —per horse power per hour . .	1.0d.
Wear and tear of machinery, rated same as for steam engines—per horse power per hour .	.15d.
Management, wages, and maintenance of works, at 2½ per cent. on cost . . .	.5d.
Total actual cost per horse power per hour .	1.65d.

This estimate is equivalent to £51 per horse power per annum, or for the total power of 1200 horses, £61,182, being the whole working expenses per annum.

But as I have estimated above, the value of a horse power to be 5.7d. per hour, so 1200 horses power per annum is worth £211,356. If therefore from this amount the working expenses are, as calculated above for water power at £61,182 per annum, be deducted, there will be a clear profit left of £150,000 a year, obtainable by leasing out the Yan Yean water works as a prime mover.

With such a source of revenue, it becomes a matter for consideration with the public, whether they will pay as the cost of their water supply £60,000 a year for interest and current expenses, and by so doing refuse an income of £211,000 a year, of which £150,000 will be clear profit, and all for the enjoyment of the coveted waters of the Plenty.

It is, however, a redeeming feature in the Yan Yean reservoir, that from its capability of being easily converted into a motive agent, the great bulk of its power may be applied reproductively to industrial purposes as a prime mover, while a fractional part of the whole will be sufficient to raise from the river Yarra the ample supply of 50 gallons a head for 100,000 persons; and thus what is now an unproductive investment as a water scheme, may be converted at once into a reproductive prime mover, and an economical means of water supply. This I will attempt to demonstrate as follows:—

Fifty gallons a head per day for 100,000 persons equals 5,000,000 gallons, or 50,000,000 lbs., which, raised 130 feet high from the Yarra, constitute a resistance to be overcome requiring 138 constant horse power, working seven days in the week, or 160 horse power, working only six days in the week To attain this available power from the reservoir, a theoretical power of 200 horses must be expended, 80 per cent. of which being the useful effect, as before stated, is 160 horse power.

But as the whole power of the reservoir theoretically is 1500 horses, occupying 112 inches in depth, so 200 horses' power will occupy only 15 inches in depth, being nearly 3,000,000 cube yards of water falling 600 feet per annum, equivalent to an effective power of 160 horses.

It is thus apparent that 15 inches in depth abstracted from the reservoir, and used as a motive power in raising the Yarra water, is all that is required therefrom for the purposes of water supply of 50 gallons a head. The residue of the water in the reservoir, or 97 inches, equal to 1300 theoretical horse power, is therefore available as a prime mover for industrial purposes.

As the annual required supply of 50 gallons a head comes to 11,000,000 cube yards, and can be raised by 160 horse power, or 3,000,000 cubic yards in the reservoir, it is hence evident that every gallon of water in the reservoir is capable of raising more than 3½ gallons of Yarra water 130 feet high for Melbourne consumption.

The importance of this fact will be more apparent when the enormous saving effected thereby in the cost of water supply, as compared with the present gravitation scheme, is considered.

I have above estimated the cost of the Yan Yean motive power, including turbines or water-wheels at 1.65d. per horse power per hour. At this rate, 160 horse power, including interest, maintenance, and management, would cost £8,157 per annum: if to this amount be added £10,000, as the interest, at 5 per cent., on £200,000 for reticulation pipes, &c., and £2000 for wages of turncocks, &c., the whole cost of water supply will be in round numbers £20,000 a year, as obtained by using a fractional part of the Yan Yean Reservoir as a motive agent in raising the Yarra water up to the tank on Eastern Hill.

The estimates of cost of the two modes of water supply, as above detailed, will therefore stand thus:

Yan Yean Gravitation Supply, as being carried out, comprising interest at 5 per cent. on £800,000, and management, wages, and maintenance, at 2½ per cent. on cost	per ann. £60,000
Supply by Yan Yean motive power, 160 available horse power raising the Yarra water	£20,000

The ratio of cost is therefore as 1 to 3 in favour of the Yan Yean as a motive power.

If I have now satisfactorily demonstrated that an economical water supply may yet be obtained, and at only one-third of the cost of the present gravitation scheme; and this by the expenditure of only a fractional part of the resources of the reservoir; it hence becomes a question of deep import as to what reproductive purposes the motive power of the reservoir may be applied.

In every civilized country the possession of flour mills is indispensable, and hence motive power to work them. The increasing agriculture of this colony, not to speak of other interests, alone will demand the establishment of motive

power throughout the country, it will be hence interesting to investigate the reproductive results of such as applied to this branch of industry. I will therefore, taking the Yan Yean Reservoir as an example of water power generally, estimate its capabilities for the manufacture of flour.

The proportion of power to the quantity of wheat ground at Mr. Fulton's mill is 4-horse power to five bushels per hour. At this rate 1200-horse power would grind fifteen hundred bushels per hour.

The actual expenses at Fulton's for labour, superintendence, and everything but steam power, is found to be 8d. per bushel.

I will assume the cost of wear and tear of motive engines, oil, and tallow, &c., to be .15 of a penny per horse power per hour, which is the actual cost in some steam engines, and is equal to .2 of a penny per bushel of wheat.

The chief item of cost will be interest on expenditure, rated at £800,000 as the cost of the Yan Yean works, fitted with mill-machinery, buildings, &c., 5 per cent. on which will be per bushel ·86 of a penny.

The cost of the bushel of ground wheat will therefore stand thus:—

Labour and superintendence, etc., etc., per bushel	8.0d
Wear, tear, oil, and tallow - - do.	.2
Interest on expenditure for works - -	.86
And allowing for maintenance of works 1 per cent. on cost - - - -	.17
Cost, per bushel by water power	9.23d

The current price in Melbourne for grinding wheat is 2s. per bushel; hence there would be a clear profit of 14¾d. per bushel, which on 36,000 bushels, the amount that could be ground in twenty-four hours by the reservoir power, would amount to £2220 per day, or at the rate of nearly £700,000 per annum.

The above calculation shows not only to what profitable account the Yan Yean reservoir might be turned to hereafter, should agriculture become so developed as to lead to an export trade in flour from Melbourne, but also the reproductive results generally to be expected from the establishment of motive power throughout the colony as applied to agricultural requirements.

It could be easily shown that there are many other industrial pursuits to which the Yan Yean motive power might be

applied as a prime mover with profitable results, not to speak of the existence of such a power forming a great incentive to the establishment of manufactories of various kinds; indeed, with such splendid facilities, rendering Melbourne independent of coal, there is nothing to prevent its becoming a great manufacturing seat but the will of the capitalist.

There is, however, one source of Victorian wealth, which has of late assumed a vast importance, and although as yet in its very infancy, bids fair to attain a magnitude to which it is impossble to assign a limit.

In the quartz reefs of Victoria there is boundless undeveloped wealth, only requiring economical motive power applied judiciously, and on a vast scale, to eliminate it from its matrix.

Great as has been the success of quartz mining, it is undeniable that in its present state it is far from satisfactory. I believe if the subject be fully investigated, it will be found that the cause of non-productiveness lies in the isolated and unsystematic mode of operation pursued in the crushing and separating. The aggregate motive power on a gold-field is represented by a number of small steam engines scattered about, each requiring a separate staff of attendants, and thus is entailed a serious loss of labour. Besides the limited scale on which operations are carried on involve an undue proportion of working expenses generally. What different results might be expected if there existed in each auriferous district or gold-field, one large crushing establishment, managed by persons professionally competent, and who, having no quartz reefs or other occupation to divide their attention, would devote themselves wholly to the economical extraction of gold from quartz, and carefully adopt improvements according as they suggested themselves. I am firmly of opinion that the problem of the economical extraction of gold from quartz will be solved, not by this or that invention, but gradually, in precisely the same manner that the railway system has attained its present perfection—by self-development, the result of lengthened experience. To obtain this comparative perfection, however, it is necessary to carry on present operations on the right track, by concentration and magnitude of working, under the direction of persons specially competent.

In the absence of large crushing establishments on the gold-fields, as above recommended, we have in the Yan Yean Reservoir (aided as it will be by the projected railways from the gold fields) a vast prime mover available for the pulverisa-

tion of quartz, and therefore capable of testing on a magnificent scale, the applicability in an economical point of view, of storage reservoirs generally to the extraction of the mineral wealth of our quartz reefs.

It may, indeed be urged against such a proposition, that the cost of carrying by railway from the gold-fields to Melbourne of the ore would neutralise any advantage due to the economy of the reservoir power; but when the difference in cost, by working on a very large scale, as compared with a very small one, is considered, as also the very superior mode of working attainable thereby, the saving in supervision and wages, besides extracting from the matrix a larger per centage of gold, due to superior appliances and scientific management, unattainable on a limited scale, the extra cost of carriage will, I believe, form an inconsiderable item when set against the economy of working. Indeed so unsatisfactory is the system of working on the gold-fields, that large shipments of quartz have been made for England, and the consequent expense of transit incurred for the purpose of economically extracting the gold. At Anderson's Creek it has been found that quartz crushed on the spot yielded only 4 ozs. to the ton, while that from the same reef sent to Melbourne for crushing yielded 10 ozs. to the ton.

There are, however, other, and as potent reasons, in an economical point of view, for conveying quartz to Melbourne for crushing at a large establishment, in the absence of motive power up the country.

Railways are about to be launched upon the colony—primarily for the public advantage; and secondarily, for profit. It cannot be expected that when opened, the traffic of the colony will be sufficient to render them remunerative at the outset, although it may be anticipated that they will eventually create a paying traffic. During the early years of their existence, therefore, they will probably be working at a loss while accommodating the public.

Should however the completion of the main lines from Melbourne to the gold-fields be simultaneous with the sudden creation of a large traffic in quartz, involving also an accompanying passenger traffic, under how much more favourable auspices would such lines be started? I shall presently show that the water power of the Reservoir is sufficient to crush and separate 2,400 tons per day, which would therefore, represent the daily amount of traffic in quartz alone; I therefore conclude, that the establishment of quartz crushing

power in Melbourne is worthy of deep consideration, if only viewed in the light of its bearing upon railway interests.

I will particularise the more prominent advantages attainable by carrying on quartz crushing in large central establishments.

In the first place, on a large scale, such as proposed, the roasting of the ore, which so greatly facilitates its being crushed, could be effected economically by means of large ovens, scientifically constructed with a view to economy of fuel and the heating of large quantities at one operation, such being impossible on a limited scale.

Also, great economy in manual labour would ensue, as will be evident to all practical men, especially when it is considered that ten separate quartz mills, of ten horse-power each, will require six men each, or sixty altogether; while one quartz mill having the aggregate power of 100 horses would probably not require more than ten men.

The wear and tear of quartz mills, which forms a most serious item of working expenses would be considerably lessened under a systemised mode of working on a large scale, as, in connection with each establishment there would necessarily exist workshops for the timely repairs and maintenance of all the machinery, the want of which, under the present isolated mode of working, is the cause of the rapid deterioration of the machinery on the gold-fields.

In addition to these considerations, it should be borne in mind that in a large systematic establishment, with its tramways, self-feeding and delivering apparatus, &c., and all the appliances that science and capital can bring to bear—it is possible to perform by machinery many minor operations otherwise requiring manual labour, and that by magnitude and concentration of working generally, there is a special economy entailed, as is evident from experience.

But not the least important of the various advantages attainable by working on a vast scale will be the arrival at comparative perfection in the economical extraction of gold from its matrix. Under the eye of an experienced mechanician, the working will suggest by its very imperfection, from time to time, the obvious improvements. It is thus that railways and locomotives have attained to what they are, as the results of lengthened experience.

I will now submit an approximate estimate of what I conceive would be the cost of quartz crushing, &c., in Mel-

bourne, carried on under the circumstances as above detailed.

It has been found in practice that one horse power, working twelve hours, is sufficient to crush to a very fine powder one ton of quartz, and perform all labour required for separating the gold; this being also a low average, I will base my estimate thereon as follows:—

Cost of crushing power per ton being—	£	s.	d.
1 horse-power, working 12 hours, at 1·65d. per hour,	0	1	8
Roasting of ore, assuming that 1 ton of wood, at 10s., will roast 10 tons of quartz in properly constructed ovens,	0	1	0
Manual labour, allowing 1 man to every 10 tons, at 20s. for wages, as deduced from the opinions of practical men engaged in quartz mining,	0	2	0
Wear and tear of quartz mills, allowing half the existing amount under improved arrangements,	0	3	6
Carriage of quartz to Melbourne—average distance of 70 miles, at 3d. per ton per mile, coal being carried on the English lines as low ¾d. per ton per mile,	0	17	6
Then adding for superintendence and contingencies, 5 per cent. on the above,	0	1	3
Total estimate,	£1	6	11

To the above estimate of 27s. per ton I would invite the scrutiny of practical men, and, if found correct, will represent a considerable saving in quartz crushing, carried on as above proposed, as compared with the existing actual cost. The present charge for quartz crushing and amalgamating on the gold-fields is about 60s. per ton, of which the actual expense is about 40s. It is hence considered that ores containing less than an ounce to the ton will not pay, and are therefore worthless. It will, therefore, be apparent that, assuming the feasibility of my estimate of 27s. per ton, a much larger return can be obtained thereby from the present paying ores; and also those now considered valueless could be worked with profit, although only yielding half-an-ounce to the ton. That such results may be obtained, under the

conditions above set forth, appears probable from the fact of precisely similar results being obtained in the Mexican mines under inferior arrangements.

As in the above estimate of 27s. per ton, the principal item of 17s. is for carriage by railway from the interior, 70 miles, some deduction must be made therefrom in favourable cases, where the cost of transport will be materially less, owing to the nearness of the mines to the crushing power.

The Anderson's Creek gold-field, rendered interesting as the locality of the first discovery of gold in Victoria, is but 15 miles from Melbourne, and with the adjacent Caledonian gold-field, comprises an auriferous district of 75 square miles. The richness of the ores from this district is now an established fact; and the frequency and abundance of the quartz reefs give token of their inexhaustible character. Although this gold-field will probably not possess the advantage of railway communication with Melbourne, it is provided by nature and position with a much cheaper and more suitable means of transport to Melbourne: the river Yarra flowing through its centre can be rendered navigable for rafts drawing 4 inches of water by the expenditure of a few thousand pounds sterling, in partly removing the reefs and other obstructions that occasionally protrude above the summer level; and thus may the Anderson's Creek gold-field possess the cheapest of all kinds of transport for its ore to Melbourne, in the form of water carriage, enhanced as such will be with the current of the river in its favour.

As, therefore, the distance of this gold-field from Melbourne is only one-fourth of that of the other gold-fields, or under 20 miles, I will assume a proportionate rate of carriage, or 5s. per ton as the cost of transport of the ore to Melbourne: this item for carriage is 12s. 6d. under that of 17s. 6d. by railway from the other gold-fields, so that all other expenses being the same, the Anderson's Creek ores can be delivered, crushed and separated in Melbourne, 12s. 6d. cheaper than the other ores, or for 14s. 6d. per ton.

Assuming the soundness of the above calculations and views, the immense importance of working the quartz reefs at the very low cost of 27s. and 14s. 6d. per ton, and thereby opening up a far more extended field for enterprise in the poorer ores that are now unworkable, must be apparent.

As all the above calculations are based on the fact that one horse-power, working twelve hours, is sufficient to crush to a fine powder, and separate, one ton of quartz, and as the

estimated water power of the Yan Yean reservoir is 1200 effectual horses, it hence follows that it is capable of crushing and separating 2400 tons in 24 hours, or in a year of 309 working days 741,600 tons.

The annual yield of gold therefore, per ounce of richness would be 741,600 ounces, which valued at £3 17s., and lessened by the cost of crushing etc. 26s., would show a clear profit per ounce of richness, of £1,854,000 per annum.

If such a result is obtainable by means of the Yan Yean reservoir applied as a motive power, from the very poor ores of one ounce per ton, that are now considered almost valueless, may it not be reasonably expected that the most magnificent returns may be obtained from the ores of average richness—say, of only three ounces per ton.

I therefore submit, from the above calculations, that by judicious management in the selection and testing of the ores at the mines before being forwarded by railway, the Yan Yean reservoir notwithstanding its immense cost can be converted into a source of wealth as a motive power, and will produce thereby great collateral benefit to railway interests, inasmuch as the traffic accruing from the carriage of 2400 tons of ore (being the estimated amount the reservoir power can crush per day) to Melbourne, rated at only 3d. per ton per mile, would amount to £650,000 per annum, not to speak of the passenger traffic that must necessarily ensue therefrom.

However to fully appreciate the value of storage reservoirs as applied to the development of mineral wealth, they must be estimated as if on the gold-fields, and not necessarily involving cost for carriage by railway. If, therefore, the cost for carriage, or 17s. 6d., be deducted from the above estimate, there will remain 9s. 6d., or say 10s., as representing the cost of crushing, etc., per ton, on the gold-fields. As, however, there will always be some carriage from the different quartz reefs to the crushing power by means of tramways, I will allow 5s. additional for carriage for an average distance of five miles. My total estimate will therefore be 15s. per ton for the extraction of gold from quartz by means of the motive power derived from storage reservoirs on the gold-fields.

According to this estimate, the Yan Yean reservoir power, if situated at Bendigo, could produce, over and above all expenses, gold to the value of £7440 per day per ounce of richness, or nearly £2,300,000 per annum.

If such amazing results can be obtained from the motive power of storage reservoirs on the gold-fields, surely the cost of their construction, although large, need not form any impediment to their being established, especially when the capitals involved therein can be so speedily reimbursed.

The verification of the above estimate will be of the utmost importance to gold mining interests, as thereby will be demonstrated the possibility of working very poor ores, having only half an ounce to the ton, with the most profitable results; and thus would the auriferous fields of Victoria be practically enlarged and thrown open to industry.

It would not require much demonstration to show, also, that the washing of auriferous earths on a large scale could be effected in the most economical manner, as the same water that gave motion to the quartz crushing and puddling machinery could afterwards be used, when its power was spent, in the washing and cradling operations. The economical importance of thus reapplying the used water will be more evident when the vast amount of manual labour that is consumed on the gold-fields in puddling and cradling is taken into consideration, being probably one-fifth of the whole labour engaged in alluvial working.

I have now attempted to show what results may be expected from the application of water power on a grand scale to the development of the mineral wealth on the gold-fields, having based my estimates on the capabilities of the Yan Yean reservoir as a prime mover; my aim having been to demonstrate that water power is for many reasons the legitimate motive power for Victoria, and not steam; and further, that in order to economically apply that power to mining industrial purposes, concentration and magnitude of working must be adopted. It is needless to state, that if my estimates can be verified, the most astounding results as regards the production of wealth, can be obtained by the timely application of capital to the construction of storage reservoirs for water power throughout the auriferous districts. That such investment of capital would be largely reproductive, I have also attempted to prove, while the power so created would be always available for agricultural or other purposes.

There are, however, apart from the above considerations, the most urgent reasons for the establishment of storage reservoirs throughout the country, arising from the periodical droughts that occur in this colony. A repetition of the great drought that occurred some years back, and lasted through

several successive seasons, may not unreasonably be expected. If the results have been so calamitous when there was only a thin and scattered population, how much more intensely would such be felt now, when the population is increased fourfold, and concentrated in various districts! In a place like Bendigo, for instance, not only would the ordinary mining pursuits be suspended for want of water, but the inhabitants would be reduced to use impure stagnant water, should not even such fail, and then would sickness, disease, and death, be engendered. It is indeed impossible to predict what extreme consequences might result to dense populations such as on the gold-fields, from a recurrence of the great drought.

With the bare possibility of being revisited with such a calamity, not to speak of its probability, does not the very existence of the mining interests demand that precautionary measures be taken to avert the consequences? That the mining districts throughout the colony, containing each from ten to fifty thousand inhabitants, might possibly be suddenly deprived of one of the first necessaries of life, is surely sufficient to awake attention to the necessity of constructing storage reservoirs against the evil day.

Viewed, therefore, in the light of reproductive investments of capital, as prime movers for the development of mineral wealth, and also as a precautionary means to be adopted against the effects of periodical droughts, I submit that the establishment of storage reservoirs at the various gold-fields is not only advisable, but absolutely indispensable, to further industrial progress and security.

It will, however, appear a serious obstacle to the realisation of the above suggestion that the amount of capital required will be so large as to induce grave doubts as to the possibility of obtaining it, notwithstanding that its investment in the manner proposed will be highly reproductive. In carrying out all great public works, however, it must be borne in mind that posterity reap the chief advantage; while the promoters, having undertaken all the expense and risk in their execution, are frequently unrewarded by immediate reproductive results. If, therefore, motive power be established in Victoria at an immense outlay, and if the nature of the works involved thereby, being of a permanent and lasting character, are serviceable for succeeding centuries, as railways are, it hence appears simply just that the cost of such works should be borne by posterity, while the present gene-

ration will have accorded all their due in originating and carrying out such, and paying the interest on their cost of construction.

If such reasoning is admittedly applicable to railway formation, I maintain it is infinitely more so to the establishment of motive power in Victoria. Railways, at best, are only auxiliaries to industrial development, while motive power is the very essence thereof. The former may be dispensed with, and have been hitherto; but motive power must be had in some form or shape. Hence it is that a large amount of capital has been expended in steam power on the gold-fields, in order to carry out the most limited operations. Experience has shown that steam power is not very well suited for the interior of this country, owing principally to the absence of the means of maintenance, and the expense of working on a limited scale. Besides, the capital expended in steam power will be for perishable works, lasting little more than one generation, and hence in that time becomes exhausted, while that expended in water power will be for an unlimited period, like railways.

Viewing the permanence and superior importance to the colony of water power over railways, the expense of its establishment presents no reasonable objection thereto, inasmuch as railways have been pronounced necessary, and their expenditure warrantable. If ten millions are about to be sunk in railways as only a means to an end, such an investment can be more judiciously made in directly promoting that end, being industrial progress, and thereby collaterally creating occupation for railways. Besides, investment in motive power will be highly reproductive, as has been shown in the preceding calculations; while it cannot be expected that railways will pay even working expenses for some years after their construction, owing to the present smallness of the population. Were ten millions invested in water power, it may be true that it would be considerably more than present requirements would demand, and might consequently for the present be unproductive; but the fact of the existence of such an industrial agent being dispersed throughout the auriferous districts, would present such an inducement to non-capitalists to follow mining pursuits, that crowds of immigrants would flock to these shores, and thus would the present wants of the colony be supplied by an increasing population.

In dealing with this important subject, I have been influ-

enced by the necessity of drawing attention to the simple fact that the absence of motive power in this colony is the great drawback to its industrial advancement. That in a place like Victoria, so incomparably rich by nature, and where manual labour is necessarily so dear, such an anomalous state of things should exist as that a large proportion of that manual labour should be absorbed in operations that are only suitably performed by machinery, appears strange indeed with the example of England for a guide. I maintain that every man engaged in work such as can be effected by machinery, as puddling or washing auriferous earth, is lost to the colony, because such a man might otherwise be most profitably engaged in skilled labour; but this state of things must unfortunately exist until motive power and machinery be brought to bear upon colonial industry. Blest as this country is by Providence with such vast natural wealth, and having also the means for obtaining loans for public works, to continue the present miserable system of developing that wealth, and to leave to the unassisted efforts of private individuals what requires a concentration of effort and capital, is but trifling with a great subject, and is a reproach to the enterprising spirit of the colonists.

In conclusion, I beg to submit the following points in my paper for your consideration.

That it is indispensably necessary to the adequate development of the mineral wealth of Victoria, that motive power, on a large scale, should be established at the various centres of industry.

That the most legitimate mode of effecting that end is by means of water power obtained from storage reservoirs, for which the physical features of the gold-fields are peculiarly favourable.

That such reservoirs as prime movers will be highly remunerative for the capital invested in their construction, and will be of incalculable benefit in time of great drought.

That with a view to render the Yan Yean Reservoir highly reproductive, it is expedient to convert it into a motive power for the crushing of auriferous quartz carried by railway from the gold fields, and for other manufacturing purposes. That Water Supply for Melbourne may be economically obtained by employing a small portion of such power in raising from the river Yarra fifty gallons a head up to the tank on Eastern Hill.

I have the honor, Mr. President and Gentlemen, to submit

the calculations and views in this paper for your consideration with the utmost diffidence, and with the humble hope that whether borne out, or otherwise, they will draw such attention to the real requirements of industrial progress as is demanded by, and only consistent with, the prospective interests of Victoria.

ART. XII.—*Museums in Victoria.*—By FREDERICK MCCOY, Esq., Fellow of the Geological Society of London, Honorary Fellow of the Cambridge Philosophical Society, and Professor of the Natural Sciences in the University of Melbourne.

THE use of museums, as a means of conveying valuable practical information to the masses of the public, has only of late years been perceived by the British people. It is only recently that the British Government has imitated the course pursued by the rulers of all the civilized states of Europe and America, and established practical Government Museums in the three kingdoms, under the titles of Museum of Practical Geology, Government School of Mines and of Science applied to the Arts, Museum of Economic Geology, Museum of Irish Industrial Resources, Museum of the School of Fine Arts, &c., and very many of even the better informed classes of the public cling to the old notion of a museum being at best a place merely for innocent amusement of schoolboys and idlers; a place, like Shakspeare's Apothecary's shop, where

> ——————" a tortoise hung,
> An alligator stuff'd, and other skins
> Of ill-shaped fishes"

might be gaped at, and where such other dusty odds and ends as stray contributors might give, should be locked in cases, without labels or classification, or other essentials, to make them useful—in fact, the more incomprehensible the objects, the better is the estimation of the lovers of these old fashioned " raree-shows "—and it is only within the last few years that our countrymen are beginning to find out that, under proper direction, and as managed in modern times, museums become the most ready and effectual means of communicating the knowledge and practical experience of the experienced few, to the many who, under less favourable circumstances, are